

Chemistry 236
Bomb Calorimetry Lab Study Problems -- Answers

1. a
2. a
3. c
4. volume
5. e (98.75 kJ/K)
6. a. $q_{\text{specific}} = -16.082 \text{ kJ/g}$
- b. $q_{\text{specific}} = -47.618 \text{ kJ/g}$ $E = -5439.4 \text{ kJ/mol}$
 $\text{C}_8\text{H}_{18} + \frac{25}{2} \text{O}_2 \rightarrow 8 \text{CO}_2 + 9 \text{H}_2\text{O}(l); \quad n_{\text{gas}} = -\frac{9}{2} \text{ mol.}$
 $H = E + (PV) = E + (nRT) = E + (n)RT = -5450.55 \text{ kJ/mol.}$
7. The slope should be slightly positive, due to the work of stirring.
8. This is essentially the case illustrated in Fig. 1. The calorimeter is sufficiently above room T that the loss of heat to the room exceeds the work of stirring. The loss is faster at the final T (larger T), so the slope is steeper after rx.
9. a. water — ~1 mL of 2000 0.05%. b. mass — ~1 mg of 1 g 0.1%.
c. T — ~0.02° of 2° 1%. Even if T can be measured to $\pm 0.01^\circ$, its error is still likely to dominate.
10. a. For a typical combustion reaction involving compounds having $M = 100$, $|n_{\text{gas}}| < 3 \text{ mol}$. [What is it for benzoic acid? Be sure you can write a balanced equation for the complete combustion of benzoic acid.] Specific heats of combustion are comparable to that for benzoic acid, -26.41 kJ/g (p. 157 of SGN). For $M = 100 \text{ g/mol}$, this gives $E = -2.6 \times 10^3 \text{ kJ/mol}$, which may be compared with $3 RT$ (@ 25°C) = 7.4 kJ/mol . Even if the ideal gas assumption is in error by 50% in this case, the resulting error is only 0.14%. This is probably much less than error from other sources (T measurement, for example), in all but the most meticulous work.
- b. If we could truly carry out the 2-step procedure outlined on pp. 145-146 of GNS, *i.e.*, carefully measure how much heat needs to be removed from the system to bring it back to the starting T , there would be absolutely no error from lack of knowledge of specific heat of the sample and sample products. Our calibration with benzoic acid essentially assumes that the calorimeter constant is independent of T in the range in which we are working, and we use this to calculate rather than measure step II. There is a very small error stemming from differences in heat capacities of benzoic acid and its products vs the unknown and its products. But considering that the sample is only ~1 g in mass *cf* 2000 g of water plus calorimeter mass, these differences should truly be negligible compared with other sources of error.
- c. From the 2-step procedure, it is clear that our result pertains to the initial T . From a practical standpoint T is so small, and likewise C_p (products – reactants -- see p. 151 of Levine), that one could probably not measure a statistically significant difference in E over this T range with this equipment.